# COTTON

## Improved Yield Potential with an Early Planting Cotton Production System

William T. Pettigrew*


### ABSTRACT

**Mid-South cotton (*Gossypium hirsutum* L.) has reached a yield plateau in recent years. Shifting the growing season earlier in the year by planting earlier may allow the crop to develop under more favorable weather patterns and escape late season insects. The objectives were to determine the effect of early planting on growth and development, lint yield, and fiber quality of cotton. Early season dry matter partitioning, early season light interception, weekly bloom counts, lint yield, yield components, and fiber quality data were collected on genotypes planted during the first week of April (early planting) and the first week of May (normal planting). The data were collected from two experiments conducted over the years 1996 to 2000. Early June leaf area index of the early planted plants was 172% greater than plants in the normal planting, which contributed to a 55% greater canopy light interception for the early planting at that time. Early planting shifted the blooming period earlier in the growing season every year but 1997. Four out of 5 yr, the early planted cotton demonstrated a 10% yield improvement over the normal planted crop. In 1997, the early planted crop was stunted by an early season cold period, and yet its yields were equivalent to the normal planted crop. Planting earlier than normal has the potential to provide for increased lint yields for Mississippi Delta cotton producers. Techniques to mitigate early cold temperature stress could help make the yield improvements found with this early planting production system more consistent.**


COTTON lint yields produced in the mid-southern USA cotton production belt are limited by the amount of sunlight received during the growing season (Pettigrew, 1994). Because we were previously able to demonstrate a strong relationship between single leaf photosynthesis averaged across the boll filling period and lint yield for a diverse group of upland cottons (Pettigrew and Meredith, 1994), this light limitation of mid-South cotton is probably more correctly a C limitation. Part of the problem is the lack of synchronicity between the peak flowering period and the longest day of the year, the summer solstice. On the summer solstice, the longest daylight period of the year occurs and should allow for the maximum amount of C fixation to occur in the photosynthetic tissue. Unfortunately, although the summer solstice occurs annually around 21 June, the peak blooming period for cotton grown in the lower Mississippi River valley alluvial flood plain (Mississippi Delta) usually occurs during the second week in July. Techniques to shift the peak blooming period closer to the summer solstice should, in theory, time the reproductive growth to develop when more C assimilates are available to support reproductive structures.

One technique to accomplish this shift in the blooming period is to plant the crop earlier than has been typically recommended for this area. The downside to this technique could be increased risk for exposure of the cotton seedlings to cold stress (Christiansen and Rowland, 1986). Exposure to cool and damp conditions can also increase the chance of seedling infections by soilborne pathogens. However, there are a number of fungicides now available that can minimize risks from seedling diseases. In addition, seed quality is better now because there is less field deterioration; the crop is harvested quicker due to use of earlier maturing varieties, faster spindle pickers, and field modules. The upside to this technique may be earlier maturing of the crop, which should minimize exposure to late season stresses such as insect infestations, high temperatures, and moisture deficits. There could also be a reduction in late-season inputs such as irrigation and insecticide applications. Soybean is an example of a crop that benefitted from late season stress avoidance by planting early (Heatherly and Spurlock, 1999).

Planting date studies for cotton have been performed in most states throughout the USA cotton production belt (Ballard and Simpson, 1925; Finley et al., 1964; Kittock et al., 1987; Cathey and Meredith, 1988). Most of the recommended optimum planting windows establish their earliest planting opportunity based on the fact that growth in the cotton plant becomes nearly inactive below 15°C (Waddle, 1984), further coupled with the objective to minimize loss from seedling disease. Many of these early studies were conducted before the new fungicides came on the market. The conservative nature of these planting recommendations avoided planting as early as theoretically possible. Some of the more recent planting date studies focused on establishing the latest planting opportunity, often in doublecropping cotton behind wheat (*Triticum aestivum* L.) (Bauer et al., 1998; Porter et al., 1996). Few have focused on pushing the planting date as early as possible.

Systems providing a degree of early seedling tolerance to exposure to chilling stress would make the benefits from early planting more consistent. Attacking the issue from a genetic standpoint is one approach. There are also reports with greenhouse and growth chamber–grown plants that certain chemicals can provide some cold

USDA-ARS, Crop Genetics and Production Research Unit, P.O. Box 345, Stoneville, MS 38776. *Corresponding author (bpettigrew@ars.usda.gov).
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**Abbreviations:** DAP, days after planting; LAI, leaf area index; NAWB, nodes above white bloom; PPFD, photosynthetic photon flux density.

tolerance. Treatment with exogenous abscisic acid (ABA) at warm temperatures has been reported to reduce injury from subsequent chilling exposure in cotton seedlings (Rikin et al., 1979, 1983). Mefluidide, a synthetic plant growth regulator, also has been reported to provide some level of chilling tolerance in several crops other than cotton (Li, 1994). The drawback is that all these compounds must be applied before the onset of the chilling event to provide any benefit. The efficacy of these compounds in the field has not been addressed.

The primary objective of these experiments was to determine whether an extremely early planting date had a yield advantage over a more normal planting date, assuming that an adequate plant stand could be established for both planting dates. The secondary objective was to determine whether chemicals thought to promote early seedling growth or enhance tolerance of seedlings to early season cold stress would be beneficial in a cotton early planting production system.

## MATERIALS AND METHODS

Two early planting field experiments were performed on a Beulah fine sandy loam (coarse-loamy, mixed, thermic Typic Dystrochrepts) near Stoneville, MS. The first experiment conducted from 1996 to 1998 utilized eight cotton genotypes, two modern adapted genotypes ('MD 51 ne' and 'SureGrow 125'), and six obsolete genotypes thought to possess some cold tolerance ('Auburn 56', 'Coker 100A', 'DeltaPine 11A T 154-2', 'Kekchi', 'M8', and 'Patty's Toole') (C.D. Ranney, personal communication, 1995). Cotton was planted on 8 Apr. 1996 and 1 Apr. 1997 and 1998 for the early planting, and 2 May 1996, 1 May 1997, and 4 May 1998 for the normal planting. Seed used to plant half the plots were treated with 8 mL $kg^{-1}$ seed of the plant growth regulator PGR-IV (Microflo, Mulberry, FL)[1], consisting primarily of gibberellic acid, indolebutyric acid, and a proprietary fermentation broth that is thought to promote early season root growth and seedling development. The experimental design used in this first experiment was a randomized complete block consisting of four replicates with a split plot arrangement of treatments. Planting dates were the main plots and subplots were the varieties and seed treatments in a factorial arrangement. Plot size was three 1 m wide by 6 m long rows in 1996 and 1997. In 1998, five 1 m wide by 6 m long rows comprised a plot. For both experiments, 0.87 kg $ha^{-1}$ PCNB (pentachloronitrobenzene), 0.22 kg $ha^{-1}$ etridiazole (5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole), and 0.87 kg $ha^{-1}$ disulfoton (*O*,*O*-diethyl S-[2-(ethylthio)ethyl] phosphorodithioate) were applied in furrow during planting for seedling disease suppression and early season insect control each year. The plots of both planting dates of the first experiment were over-sown and then hand-thinned at the first or second true leaf stage to a population density of 65 000 plants $ha^{-1}$ each year. Over-seeding and hand thinning the plots ensured adequate plant populations at both planting dates and allowed us to focus on whether plants established earlier in the season had growth and yield advantages over plants established during the more standard planting dates.

The second experiment was conducted from 1999 to 2000 using four modern cotton genotypes ('DeltaPine 20B', 'FiberMax 832', 'Paymaster 1220 BG/RR', and 'Phytogen PSC 952'). These genotypes were chosen to represent a range of maturities. The early planting of the cotton occurred on 1 April in both 1999 and 2000. The normal planting occurred on 1 May during both years. Soil crusting caused an inadequate stand to be established with the normal planting in 1999 and necessitated that the normal planted plots be replanted on 10 May. For each planting date, shortly after emergence, the plots were treated with one of four foliar-applied treatments. These foliar treatments were a (i) 0.14 kg $ha^{-1}$ ethephon ((2-chloroethyl)phosphonic acid), (ii) 14 g $ha^{-1}$ mefluidide (*N*-[2,4-dimethyl-5-[[(trifluoromethyl)sulfonyl]amino]phenyl] acetamide), (iii) 3 g $ha^{-1}$ mefluidide and diethanolamine [bis (2-hydroxyethyl)amine] mixture, and (iv) a control receiving only water. The nonionic surfactant Tween 20 (Sigma, St. Louis, MO) was included in the mixture of all foliar treatments. Foliar treatments were applied to the plots using a $CO_2$-powered back pack sprayer at a rate of 160 L $ha^{-1}$. Applications were made to the early planting on 14 Apr. 1999 and on 21 Apr. 2000. Foliar applications to the early plantings were timed to be applied after emergence but at least 24 h before exposure to cool temperatures. Air temperatures dropped to 5°C after foliar treatments in 1999 and to 8°C in 2000. Foliar treatments were applied to the late planting on 25 May 1999 and 23 May 2000. A split plot arrangement of treatments in a randomized complete block design with four replicates was also utilized for this second experiment. Planting dates were the main plots and subplots were the genotypes and foliar applied treatments in a factorial arrangement. Plot size in the second experiment was five 1 m wide by 6 m long rows. Each year, the plots of both planting dates were oversown and then hand-thinned to a population density of 97 000 plants $ha^{-1}$.

The percentage of photosynthetic photon flux density (PPFD) intercepted by the canopies of both experiments was determined with a LI 190SB point quantum sensor (LiCor, Lincoln, NE) positioned above the canopy and a 1 m long LI 191SB line quantum sensor placed on the ground perpendicular to and centered on the row. Two measurements were taken per plot with the average of those two measurements used for later statistical analysis. These PPFD interception data were collected on 16 June 1998 in Exp. 1 and on 21 June 1999 and 8 June 2000 in Exp. 2.

Dry matter harvests were taken on 9 June 1998 for Exp. 1 and on 15 June 1999 and 6 June 2000 for Exp. 2. One of the inner plot rows was designated for use in the dry matter harvests. On each harvest date, the aboveground portions of plants from 0.3 m of row were harvested and separated into leaves, stems and petioles, and squares. Leaf area index (LAI) was determined using a LI-3100 leaf area meter (LiCor, Lincoln, NE) and main stem nodes were counted. Samples were dried for 48 h at 70°C and dry weights were recorded.

The number of white blooms (blooms at anthesis) per plot were counted on a weekly basis to document the blooming rate throughout the growing season. These counts were initiated at the first sign of blooming and were continued until production of blooms had virtually ceased. Counts were collected every year for both experiments.

Yield was determined for both experiments each year by hand-harvesting 4.6 m of row length from an inner plot row that was not used in the dry matter harvest, avoiding the ends of the row. The two planting dates were always harvested on the same dates. Four hand-harvests were made in 1996, 1997, 1998, and 1999. Only three hand-harvests were made in 2000. The number of bolls harvested per plot were counted on each harvest date. Boll mass was determined by dividing the seed cotton harvested per plot by the number of bolls harvested per

[1] Trade names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product or service, and the use of the name by USDA implies no approval of the product or service to the exclusion of others that may also be suitable.

plot. Average seed mass was determined from 100 nondelinted seeds per plot.

After ginning, lint samples were sent to Starlab Inc. (Knoxville, TN) for determination of various fiber quality parameters. Fiber bundle strength and fiber elongation were determined with a stelometer. Span lengths were measured with a digital fibrograph. Fiber maturity, wall thickness, and perimeter were calculated from arealometer measurements.

All weather data were collected at an official weather station located about 0.8 km from the experimental site. Thermal units were calculated as:

$$[(\text{Maximum air temperature} + \text{Minimum air temperature}) \div 2] - 15.5°\text{C}$$

Cumulative early season cold units were calculated as described by Kittock et al. (1987):

$$\Sigma\ (10°\text{C} - \text{Daily minimum air temperature if} \leq 10°\text{C}) \text{ from planting to 31 May.}$$

Statistical analyses were performed using analysis of variance. Planting date main effect means were averaged across genotypes and seed treatments (Exp. 1) or foliar treatments (Exp. 2) when the interactions were not significant or meaningful. Means were separated by use of a protected LSD at $P \leq 0.05$.

**Table 1. Daily soil maximum and minimum temperatures at 5 cm depth and early season cold unit accumulation for each planting date from 1996 to 2000 at Stoneville, MS.†**

| | Early plant | | | Normal plant | | |
|---|---|---|---|---|---|---|
| | Soil temperature | | | Soil temperature | | |
| Year | Max | Min | Cold units‡ | Max | Min | Cold units |
| | C° | | | C° | | |
| 1996 | 13.9 | 3.9 | 30 | 27.2 | 13.9 | 0 |
| 1997 | 23.3 | 11.1 | 61 | 26.1 | 16.1 | 1 |
| 1998 | 21.7 | 12.2 | 31 | 31.1 | 18.3 | 0 |
| 1999 | 18.3 | 12.8 | 11 | 28.3 | 17.2 | 0 |
| 2000 | 24.4 | 11.7 | 27 | 31.1 | 18.9 | 0 |

† All observations made by NOAA, Mid-South Agric. Weather Service, and Delta Research and Extension Center Weather (H.C. Pringle III), Stoneville.

‡ Cold units = Σ (10°C − Daily minimum air temperature if ≤10°C) from planting to 31 May.

## RESULTS

For both experiments, daily maximum and minimum soil temperatures at a 5-cm depth under grass were considerably lower on the early planting dates than on the normal planting dates (Table 1). Each year, on dates when the early planting occurred, the 5-cm depth daily minimum temperature dipped below the 15°C threshold at which cotton growth becomes mostly inactive (Waddle, 1984). Minimum soil temperature on the normal planting date dipped below this growth threshold only in 1996. Nevertheless, adequate stands were obtained after thinning for each planting event. The seedling survival rate at 30 days after planting (DAP) for the early planted plots (counted before thinning) was 84% in 1996, 60% in 1997, and 79% in 1998.

For the first experiment, no significant meaningful interactions were detected between genotypes and planting dates, or seed treatments and planting dates for any of the data gathered. This lack of interaction between genotypes and planting dates indicates that the six obsolete genotypes thought to possess some cold tolerance (Auburn 56, Coker 100A, DeltaPine 11A T 154-2, Kekchi, M8, and Patty's Toole) performed no better when grown under early planted cooler conditions than did the modern genotypes (MD 51 ne and Suregrow 125) (data not shown). The PGR-IV seed treatment had no significant effect on any of the data collected from either planting date (data not shown). Similarly, none of the foliar spray treatments had any measurable effects on the data collected for either planting date during the second experiment (data not shown). Due to these lack of meaningful interactions, planting date means were averaged across both genotypes and seed treatments for the data presented for the first experiment and across genotypes and foliar spray treatments for the second experiment.

Dry matter partitioning and canopy light interception data collected during the prebloom growth period for the last year of the first experiment (1998) and for both years of the second experiment demonstrate the greater early season growth in the early vs. normal plantings (Table 2). Averaged over the 3 yr, canopy light interception

**Table 2. Planting date effects on sunlight interception and dry matter partitioning averaged across genotypes and treatments for the years 1998 to 2000.**

| Planting date | % Canopy light interception | Plant height | Main stem nodes | Height/ node ratio | Leaf area index | Vegetative wt. | Reproductive wt. |
|---|---|---|---|---|---|---|---|
| | % | cm | nodes plant$^{-1}$ | | | g m$^{-2}$ | |
| | | | 1998 | | | | |
| Early | 42.8 | 35 | 13.3 | 2.6 | 0.79 | 68.5 | 0.9 |
| Normal | 37.3 | 27 | 9.4 | 2.9 | 0.47 | 38.5 | 0.1 |
| LSD (0.05) | 4.0 | 1 | 0.5 | 0.2 | 0.04 | 4.5 | 0.4 |
| *P* > *F* | 0.02 | 0.01 | 0.01 | 0.04 | 0.01 | 0.02 | 0.02 |
| | | | 1999 | | | | |
| Early | 50.8 | 46 | 16.0 | 2.9 | 1.08 | 117.3 | 4.5 |
| Normal | 27.4 | 23 | 9.6 | 2.4 | 0.29 | 26.3 | 0.0 |
| LSD (0.05) | 0.6 | 1 | 0.6 | 0.1 | 0.07 | 13.4 | 1.2 |
| *P* > *F* | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | | | 2000 | | | | |
| Early | 25.9 | 25 | 12.4 | 2.3 | 0.44 | 37.3 | 0.9 |
| Normal | 15.8 | 20 | 8.3 | 2.0 | 0.16 | 14.2 | 0.0 |
| LSD (0.05) | 2.9 | 1 | 0.3 | 0.1 | 0.07 | 7.9 | 0.3 |
| *P* > *F* | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

**Table 3. Monthly weather summary for 1996 to 2000 at Stoneville, MS.†**

| Month | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|
| | | | Precipitation, cm | | |
| April | 15.0 | 11.3 | 11.0 | 16.1 | 28.2 |
| May | 6.2 | 14.8 | 11.7 | 14.5 | 17.6 |
| June | 13.3 | 10.6 | 4.0 | 7.1 | 15.6 |
| July | 8.4 | 7.4 | 14.5 | 2.6 | 1.6 |
| August | 11.0 | 7.1 | 1.8 | 0.6 | 0.0 |
| September | 11.2 | 5.6 | 7.4 | 4.4 | 6.6 |
| October | 7.3 | 11.5 | 2.2 | 3.1 | 1.5 |
| | | | Thermal units‡ | | |
| April | 79 | 38 | 79 | 156 | 65 |
| May | 301 | 172 | 289 | 235 | 269 |
| June | 325 | 297 | 375 | 334 | 333 |
| July | 381 | 408 | 424 | 403 | 401 |
| August | 329 | 336 | 397 | 401 | 432 |
| September | 230 | 270 | 338 | 254 | 266 |
| October | 98 | 115 | 164 | 120 | 147 |
| | | | Solar radiation, MJ $m^{-2}$ | | |
| April | 583 | 580 | 544 | 546 | 513 |
| May | 732 | 710 | 667 | 703 | 598 |
| June | 655 | 670 | 733 | 649 | 619 |
| July | 672 | 767 | 693 | 712 | 733 |
| August | 601 | 683 | 626 | 715 | 690 |
| September | 525 | 562 | 523 | 547 | 492 |
| October | 440 | 447 | 453 | 483 | 460 |

† All observations made by NOAA, Mid-South Agric. Weather Service, and Delta Research and Extension Center Weather (H.C. Pringle III), Stoneville.
‡ [(Max. temp + Min. temp.) ÷ 2] − 15.5°C.

was 55% greater and LAI was 172% greater in plots of the early planting at this sampling compared with plots of the normal planting. Each year, by this early June sampling, plants in the early planting had shifted some of their dry matter production into reproductive growth (fruiting buds). Only in 1998, however, had the normal planted plants initiated reproductive growth by this sampling date. Dry matter production and light interception differences between planting dates were more pronounced in 1999 due the greater thermal unit accumulation (Table 3) and reduced cold unit accumulation (Table 1) during April in 1999 compared with 1998 or 2000 (Table 3).

Attaining various growth stages earlier in the year by the early planted plants is further reflected by a shift in the blooming period to earlier in the year compared with the normal planted plants (Fig. 1 and 2). In every year of both experiments, significantly more early season blooms were produced by plants in the early planting than by plants in the normal planting. During 1996 with the first experiment, the peak blooming rate of plants in the early planting occurred 14 d earlier than the peak bloom of plants in the normal planting (Fig. 1). There was no appreciable shifting of the peak blooming rate in the remaining 2 yr (1997–1998) of the first experiment. In 1997, a severe cold stress affected the early planted plants shortly after emergence, with air temperatures dipping to 2°C on 13 and 14 April. This cold period damaged the cotyledons and, when combined with the additional cold units experienced by the early planted plants in April of that year (Table 1), severely stunted the growth of these young seedlings. By the time the growth of these stunted seedlings had fully recovered, the seedlings from the normal planting were beginning to emerge. The cold damage and stunting suffered by the early planted seedlings meant that the growth pattern of plants in the two planting dates essentially mirrored each other throughout the remainder of the growing season, resulting in no appreciable shift of the peak bloom that year.

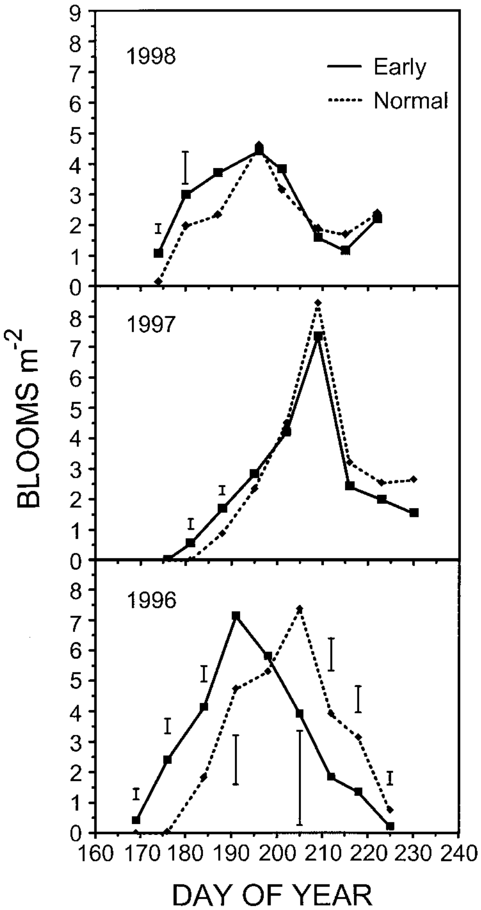


**Fig. 1. White blooms (blooms at anthesis) $m^{-2}$ of ground area at various times throughout the 1996–1998 growing seasons in early planted and normal planted cotton production systems. Vertical bars denote LSD values at the 0.05 level.**

Similar blooming patterns were observed for the planting dates in the second experiment. In 1999, the peak bloom was shifted approximately 3 wk earlier in the early planting compared with the normal planting (Fig. 2). This earlier peak bloom can be attributed to high thermal unit accumulation in April (Table 3) and to the replanting of the normal planting on 10 May because of poor stand establishment from the initial seeding. During the 2000 growing season, there was no appreciable shifting of the peak bloom between the planting dates, but considerably more blooms were produced early in the season in the early planted treatment compared with the normal planting. In both studies, the earlier attainment of various developmental stages by the early planted crop meant that its growing season had been shifted to earlier in the calender year, not that fewer days after planting or reduced thermal units were required to reach the various growth stages.

In both experiments, planting date altered the lint yield

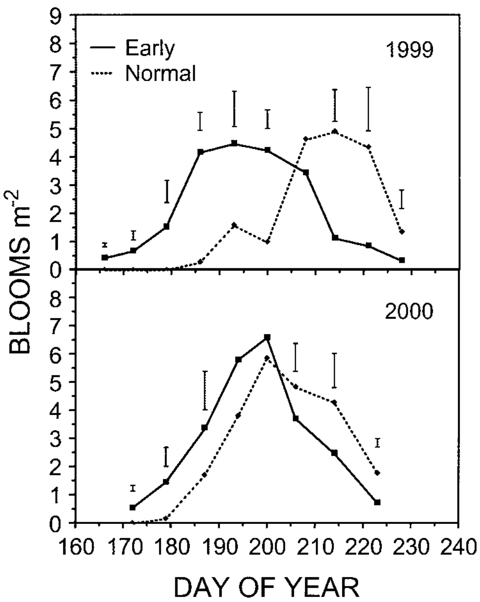


**Fig. 2. White blooms (blooms at anthesis) $m^{-2}$ of ground area at various times throughout the 1999–2000 growing seasons in early planted and normal planted cotton production systems. Vertical bars denote LSD values at the 0.05 level.**

production and yield components. Even though a significant year × planting date interaction prevented averaging planting date means across years, similar variances among years allowed for a pooling of error terms across years to test for significance using a combined analysis. Therefore, only one LSD for each experiment was produced to separate planting date means within years.

In 2 out of the 3 yr of the first experiment, early planted cotton yielded significantly more lint (about 8%) than did cotton in the normal planting (Table 4). The yield components primarily responsible for this lint yield increase in 1996 were the number of bolls $m^{-2}$ and lint percentage. The previously mentioned early season cold stress combined with the exposure of the early planted crop to substantially more cold units in 1997 (Table 1) limited the yield performance of the early planted crop. Nonetheless, plants in the early planting yielded comparable to plants in the normal planting in 1997. In 1998, boll mass was 6% greater, seed mass was 3% greater, and lint index was 7% greater for the early planting compared with the normal planting. Maturity for the early planted crop (as demonstrated by % first harvest) was reached earlier in the year than the normal planted. On average, 76% more of the total lint yield was picked on the first harvest for the early planted cotton compared with the normal planted.

Both years in the second experiment, the early planted plants yielded an average 25% more lint than the normal planted plants (Table 5). A greater number of bolls $m^{-2}$ (29% more in 1999 and 10% more in 2000) contributed to the yield increase of the early planting. In 1999, an 8% larger boll mass also contributed to the yield increase of early planting.

Most fiber quality traits were not affected by planting date in either experiment. The lack of interaction between planting dates and years allowed for averaging planting date means for each experiment across years. Fiber elongation was the only fiber trait consistently affected by planting date. In the first experiment, the fiber elongation was 3% lower for fiber from the early planting compared with fiber from the normal planting (Table 6), while in the second experiment, fiber elongation was reduced 4% by early planting (Table 7). The 2.5% span length of fiber from the early planting of the second experiment was 2% shorter than fiber from the normal planting.

Planting cotton earlier than normal allows the crop to develop its canopy earlier and intercept more of the early season sunlight (Table 3). With the longest daylight period of the year occurring on the summer solstice, potentially more sunlight is available for photosynthesis and growth. This shifting of the growing season allowed the early planted crop to initiate reproductive growth earlier and produce more blooms earlier in the year (Fig. 1 and 2). Producing blooms earlier in the season allows the early planted plants to set more of

**Table 4. Planting date effects on lint yield and yield components averaged across genotypes and treatments for the years 1996 to 1998.**

| Planting date | Lint yield | % First harvest | Boll mass | Boll no. | Lint % | Seed mass | Lint index |
|---|---|---|---|---|---|---|---|
| | kg ha$^{-1}$ | % | g | bolls m$^{-2}$ | % | mg | mg seed$^{-1}$ |
| | | | | 1996 | | | |
| Early | 1003 | 62.2 | 4.66 | 62 | 35.3 | 98 | 54 |
| Normal | 900 | 28.0 | 4.75 | 56 | 34.1 | 103 | 53 |
| LSD (0.05) | 64 | 3.3 | 0.17 | 5 | 0.6 | 2 | 2 |
| *P* > *F* | 0.01 | 0.01 | 0.25 | 0.02 | 0.01 | 0.01 | 0.57 |
| | | | | 1997 | | | |
| Early | 916 | 38.7 | 4.78 | 55 | 35.0 | 109 | 59 |
| Normal | 935 | 26.1 | 4.65 | 57 | 35.4 | 109 | 60 |
| LSD (0.05) | 64 | 3.3 | 0.17 | 5 | 0.6 | 2 | 2 |
| *P* > *F* | 0.51 | 0.01 | 0.10 | 0.36 | 0.21 | 0.92 | 0.27 |
| | | | | 1998 | | | |
| Early | 659 | 37.3 | 4.10 | 48 | 33.5 | 97 | 49 |
| Normal | 568 | 23.5 | 3.88 | 45 | 32.9 | 94 | 46 |
| LSD (0.05) | 64 | 3.3 | 0.17 | 5 | 0.6 | 2 | 2 |
| *P* > *F* | 0.01 | 0.01 | 0.02 | 0.16 | 0.06 | 0.02 | 0.01 |
| | | | | 3-yr mean | | | |
| Early | 859 | 46.1 | 4.51 | 55 | 34.6 | 101 | 54 |
| Normal | 801 | 25.9 | 4.42 | 53 | 34.1 | 102 | 53 |

**Table 5. Planting date effects on lint yield and yield components averaged across genotypes and treatments for the years 1999 and 2000.**

| Planting date | Lint yield | % First harvest | Boll mass | Boll no. | Lint % | Seed mass | Lint index |
|---|---|---|---|---|---|---|---|
| | kg ha$^{-1}$ | % | g | bolls m$^{-2}$ | % | mg | mg seed$^{-1}$ |
| | | | | 1999 | | | |
| Early | 1181 | 56.7 | 4.70 | 67 | 37.9 | 97 | 59 |
| Normal | 847 | 9.7 | 4.35 | 52 | 37.7 | 101 | 61 |
| LSD (0.05) | 80 | 3.9 | 0.26 | 4 | 0.9 | 2 | 3 |
| *P* > *F* | 0.01 | 0.01 | 0.02 | 0.01 | 0.58 | 0.01 | 0.26 |
| | | | | 2000 | | | |
| Early | 1162 | 52.8 | 4.82 | 69 | 36.3 | 97 | 56 |
| Normal | 1036 | 26.4 | 4.63 | 63 | 36.2 | 95 | 54 |
| LSD (0.05) | 80 | 3.9 | 0.26 | 4 | 0.9 | 2 | 3 |
| *P* > *F* | 0.01 | 0.01 | 0.12 | 0.01 | 0.76 | 0.08 | 0.31 |
| | | | | 2-yr mean | | | |
| Early | 1172 | 54.8 | 4.76 | 68 | 37.1 | 97 | 57 |
| Mean | 941 | 18.1 | 4.49 | 58 | 36.9 | 98 | 58 |

**Table 6. Planting date effects on fiber quality traits averaged across genotypes, treatments, and years (1996–1998).**

| Planting date | Fiber strength | Fiber elongation | Span length 2.5% | Span length 50% | Fiber micronaire | Fiber maturity | Fiber perimeter |
|---|---|---|---|---|---|---|---|
| | kN m kg$^{-1}$ | % | cm | cm | | % | μm |
| Early | 195 | 7.6 | 2.81 | 1.40 | 4.24 | 83.7 | 46.8 |
| Normal | 193 | 7.8 | 2.80 | 1.40 | 4.23 | 83.9 | 46.7 |
| LSD (0.05) | 2 | 0.1 | 0.02 | 0.01 | 0.53 | 7.87 | 0.6 |
| $P > F$ | 0.07 | 0.01 | 0.45 | 0.84 | 0.97 | 0.93 | 0.82 |

**Table 7. Planting date effects on fiber quality traits averaged across genotypes, treatments, and years (1999 and 2000).**

| Planting date | Fiber strength | Fiber elongation | Span length 2.5% | Span length 50% | Fiber micronaire | Fiber maturity | Fiber perimeter |
|---|---|---|---|---|---|---|---|
| | kN m kg$^{-1}$ | % | cm | cm | | % | μm |
| Early | 211 | 7.4 | 2.87 | 1.42 | 4.18 | 82.4 | 48.7 |
| Normal | 215 | 7.7 | 2.92 | 1.45 | 4.14 | 80.7 | 49.1 |
| LSD (0.05) | 49 | 0.2 | 0.01 | 0.07 | 1.81 | 35.6 | 0.8 |
| $P > F$ | 0.51 | 0.01 | 0.01 | 0.29 | 0.80 | 0.66 | 0.38 |

their bolls utilizing the beneficial rains and sunlight that typically occur in June and July (Table 3). Plants in the normal planting set the majority of their bolls during the later half of July and early August, typically a hotter and drier period of the year.

Shifting the reproductive growth to periods of the year that historically have favorable weather patterns, allowed the early planted cotton to produce 10% higher yields in 4 out of the 5 yr across the two experiments (Tables 4 and 5). While the additional sunlight during reproductive growth undoubtedly helped, avoiding having to set the majority of the bolls during late July and August, which is historically the hottest and driest time of the year at Stoneville (Boykin et al., 1995), was probably the primary reason behind the yield increases observed with early planting. In addition, the earlier maturity of the crop provided by early planting may allow elimination of some late season inputs such as additional insecticide treatments or irrigation. The risk of early season cold temperature stress was evident for the early planted crop during the only year (1997) that planting date demonstrated no yield increase. Even though the plants sustained stunting from the early cold stress that year, there was not a yield penalty incurred relative to the 1 May planting by gambling to plant earlier than normal. The development of cotton genotypes with enough early season cold tolerance to be able to withstand early season cold stress should contribute to more consistent yield increases from planting early.

Attempts to mitigate problems arising from cold temperature stress during early planting via chemical means were not successful. Neither the PGR-IV seed treatment from the first experiment nor the foliar applications of mefluidide, or a mixture of mefluidide and diethanolamine, or ethephon from the second experiment had any demonstrable effect on plant growth or yield relative to the untreated control, even during the 1997 growing season when the severe cold period occurred (data not shown). This lack of effectiveness of these compounds in imparting cold tolerance to cotton could be because the compounds simply may not work in this regard in a field situation or because the cold stress either did not occur or was so severe that it overwhelmed any degree of cold tolerance that these compounds may have imparted. In addition, the timing of application of the foliar compounds in the second experiment may not have been optimized since they needed to be applied before the onset of cold stress.

In conclusion, an early planted production system for cotton has potential to produce increased lint yields for cotton producers. In achieving this potential yield boost, early planting shifts the risks from the high temperatures, moisture deficits, and high insect infestations found late in the growing season to cold temperature stress and seedling disease pressure early in the year. In addition, earlier planting dates may could give producers more options in spreading their risks over a wider range of planting dates. To make the yield increases more consistent, new cotton genotypes with increased early season cold tolerance need to be developed to address this shift in risk from late season to early season stresses. Seeding rates and other production practices that are needed to ensure adequate stand establishment under the more stressful conditions connected with early planting need to be defined and optimized. These results should also be validated in larger plots that are spindle-picked.

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